Summer 2005

Swoosh and Boom

QUARTERLY

Indian Head Division

N S W C

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Cover: The U.S. Navy's Fire Scout vertical takeoff and landing tactical unmanned aerial vehicle before a day of developmental flight tests at the Webster Field Annex onboard Naval Air Station (NAS) Patuxent River. Smart launcher weaponization is being considered for the Fire Scout (see article on page 3). Official U.S. Navy photo by Kurt Lengfield.

Swoosh and Boom Quarterly is published by the Naval Sea Systems Command, Indian Head Division, Naval Surface Warfare Center (IHDIV/NSWC). Articles and other contributions are welcome. IHDIV/NSWC reserves the right to make editorial changes. Views expressed are those of the authors and are not necessarily those of IHDIV/NSWC. All photos courtesy of IHDIV/NSWC unless otherwise credited. Distribution Statement A: Approved for public release; distribution is unlimited.

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Indian Head Division
Naval Surface Warfare Center

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On May 26 2005, Indian Head Division had the opportunity to recognize over 100 employees for their outstanding accomplishments in the areas of innovation, safety, teaming, customer service, patents, Lean, management, and community service to name a few.

This was the second year I have participated in this annual ceremony. To be able to recognize these individuals and their achievements is a highlight for me – it never ceases to amaze me what talented and extraordinary folks I am privileged to have on the Indian Head Division team.

The recent recommendations of the DOD Base Realignment and Closure process identified Indian Head Division as the DOD Energetics Center. This endorsement recognizes the key capabilities and expertise of Indian Head Division in the critical national competency of energetics materials research, development, acquisition, and test and evaluation. For over 115 years, the talents of the Indian Head workforce have, and continue to, play one of the key roles in keeping the nation's warfighting spear razor-sharp.

For over a century, the men and women of Indian Head Division have system-engineered energetics products and services for our sailors, soldiers, airmen, and marines, enabling them to promote democracy and sustain peace around the world. As we look to the future, we see the DOD Energetics Center shaping the next generation of national defense tools—smaller, higher precision, smarter, more insensitive, yet better performing ordnance—providing the right weapon on the right target at the right time.

This Summer Edition of the *Swoosh and Boom* is another testament to the Indian Head Division's talent in the energetics arena. You will read about the advancements Indian Head Division energetic experts are making in the areas of Combat Safe Insensitive Munitions, weaponization of unmanned aerial vehicles, Joint Distance Support and Response, and primers for aircrew ejection seats. In addition, we have highlighted a few of our recent contributions to the Global War on Terrorism, with updates on the Large Package X-Ray Apparatus (LAPAXA), Short Range Assault Weapon (SRAW), the Integrated Maritime Portable Acoustic Scoring and Simulator (IMPASS), Zuni Rocket launchers, and improving the 2.75-Inch Rocket Flechette Warhead.

As the DOD Energetics Center, Indian Head Division is the "go to" organization to solve the problems of our warfighters, providing the technical excellence needed to provide energetics solutions that are effective, reliable, and safe. Energetic materials are uniquely military, and this edition of the *Swoosh and Boom* is another shining example of why Indian Head Division continues to be a national asset.

Standard Missile

SMAW-NE

MEMS

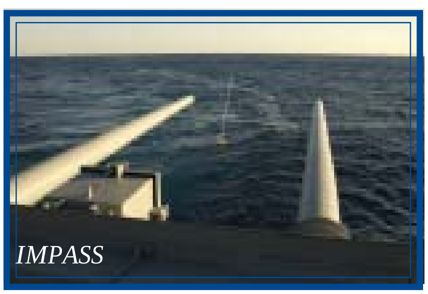
We ensure operational readiness of the United States and allied forces by providing technical capabilities necessary to rapidly move any “energetics” product from concept through production, to operational deployment. Our capabilities include: research, development, testing, and engineering; acquisition; manufacturing technology; manufacturing; industrial base, fleet, and operational support for warheads; explosives; propellants; pyrotechnics; energetic chemicals; rocket, missile, and gun propulsion systems; missile simulators, trainers, and test and diagnostic equipment; tri-service cartridge-actuated devices, propellant-actuated devices, and aircrew escape propulsion systems; and other ordnance products.

Our capabilities provide technical expertise for special weapons, explosive safety, and ordnance environmental support. These technical capabilities and this expertise support all Naval warfare areas as well as the Army, Air Force, and private sector.

Tomahawk

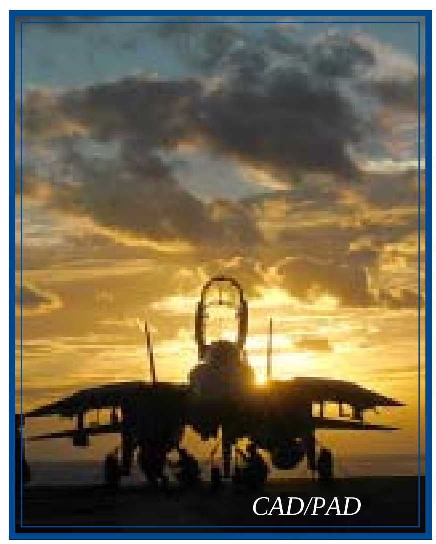
Sea Sparrow

Torpedo



IMPASS

Warhead Explosion



CAD/PAD

IHDIV Develops UAV Weaponization Kit

by Kenneth Johnson
Weapons Department

The Weapons and Weapons Simulation Departments at the Indian Head Division, Naval Surface Warfare Center (IHDIV) supported a 2.75-inch rocket safe separation demonstration in December 2004—the last step in establishing the effects that rocket launch would have on a lightweight rotorcraft such as the Vigilante™ unmanned aerial vehicle (UAV).

While UAVs are used primarily for reconnaissance and surveillance missions, they are becoming more versatile as new roles and applications are considered. The integration of weapons onto these aircraft would greatly enhance their utility to the warfighter by providing the UAV a means for prosecuting targets of opportunity.

The mission versatility, operating range, size, weight, and cost of 2.75-inch rockets make them a natural choice for integration onto a UAV. These rockets are capable of killing lightly armored targets, such as technicals (civilian trucks carrying a weapon, such as a 0.50-caliber machine gun or rocket-propelled grenade).

The Vigilante™ unmanned aerial vehicle equipped with a smart launcher (left side of photo) and an imaging pod (right side) that captured electro-optic/infrared camera imagery. The imagery was relayed to the payload operator aboard the UH-1 "Huey" helicopter.

During the safe separation demonstration, the rocket firings were controlled by a payload operator aboard a UH-1 "Huey" helicopter. Rudimentary targeting was accomplished by relaying electro-optic/infrared (EO/IR) camera imagery from the UAV to the payload operator.


A rocket is fired from the Vigilante™ unmanned aerial vehicle on 13 December 2004 during the safe separation demonstration. The firing did not adversely affect the UAV's flight characteristics.

The Vigilante™ was the first UAV to take advantage of the four-tube Hydra Universal Rail Launcher with Integral Intelligence (HURL/II) consisting of an Army-developed structure and a Navy-developed electronic assembly. The “smart” launcher electronics not only increase the safety and flexibility of rocket firing, but also provide other useful capabilities, such as logging of inventory and condition-based maintenance data.

Initial modeling, simulation, and analysis conducted at IHDIV, along with subsequent ground firings from a UAV mock-up at the Army's Yuma Proving Ground, indicated a significant recoil force from rocket exhaust on the launch platform.

Traditionally for the rocket to fire, it must exert a holdback force of up to 600 lb to overcome the device securing it in the launcher. In this case, the UAV did not have to overcome the holdback force because HURL/II contained a new, Army-designed rotating retainer, or “rotainer,” that releases the rocket upon motor ignition, but still secures the rocket in the launcher through crash or collision circumstances.

A simulation using a computer model of the aircraft, the UAV's actual autopilot, and a synthesized rocket exhaust profile indicated that, although the Vigilante™ would dive somewhat as a result of rocket firing, it would remain stable. None of the airborne firings has adversely affected the UAV's flight characteristics.

The firings not only pointed toward the likelihood of successfully employing both current unguided and future guided rockets from lightweight UAVs, but also demonstrated that even unguided rockets could be integrated into the UAV's control system through the use of a “smart” launcher.

The HURL/II implements a MIL-STD-1760 carriage store interface; however, instead of using a standard connector, the launcher mates with a Hellfire Missile rail.

In addition to developing a MIL-STD-1760-compliant launcher, IHDIV was instrumental in developing the UAV's stores management system (SMS). The SMS controls and monitors the operational state of aircraft-installed stores. It also provides and manages the communications between stores and other aircraft subsystems. IHDIV provided the user interface to the launcher in the Vigilante™ control station to ensure rocket control safety features were present in all subsystems, whether aboard the UH-1 or the UAV.

Thanks to this successful demonstration, other UAVs now can take advantage of the HURL/II. For example, the Fire Scout program is currently considering this smart launcher for its weaponization effort.

Detachment Seal Beach, JDSR Support the Warfighter in Operation Iraqi Freedom

by Lawrence Lee
Strategic Systems Evaluation Department
Seal Beach Detachment

Indian Head Division, Naval Surface Warfare Center (IHDIV/NSWC), Detachment Seal Beach is providing software engineering support for the Joint Distance Support and Response (JDSR) Advanced Concept Technology Demonstration (ACTD), one of the many technologies being deployed in support of Operation Iraqi Freedom.

JDSR creates an integrated technical data environment whereby technical data, training, and maintenance information is readily available and accurate for the warfighter. This information is delivered more quickly and less expensively than conventional support. JDSR provides near-real-time, reliable, accurate tele-maintenance for forward deployed forces using a collaborative knowledge center and tool suite with reach-back capabilities.

The JDSR ACTD is managed under Deputy Under-Secretary of Defense for Advance Systems and Concepts and is sponsored by U.S. Joint Forces Command (USJFCOM) and the Navy's U.S. Fleet Forces Command (USFLTFORCOM). The Navy is the service lead, with NSWC Crane as the technical lead on this project.

The JDSR ACTD utilizes tele-maintenance already developed by the different Services, such as Distance Support (DS), Remote Technical Assistance Support System (RTASS), and Joint Aviation Technical Data Integration (JATDI), and augments it with

Sailors aboard the USS Mason are currently using JDSR capabilities to streamline technical data and maintenance information. Official U.S. Navy photo.

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Detachment Seal Beach successfully modified MAP software to operate on the JDSR ruggedized portable server. JDSR ruggedized laptops in the field communicate with the server via satellite connections.

a common e-tool kit to allow the maintainer to see video, view technical manuals, and even drill down into schematic drawings.

It also allows the maintainer to communicate directly with subject matter experts (SME) halfway around the world to solve complicated repairs in the field. JDSR enables quicker diagnosis and repair times.

The goal of the project is to bring together the different Service and industry solutions into a "best of breed" with emphasis on common problems such as secure communications and bandwidth limitations. The result provides the user with the capability for faster diagnosis and repair times.

During the development and test time period, demonstrations of capability will occur to assess military utility with numerous excursions to gain insight for product improvement.

The first operational demonstration took place in July of 2003. The JDSR team successfully demonstrated Air Force live linkage and connectivity among many geographically dispersed sites including Spangdahlem Air Force Base (AFB), Germany; Kapaun Air Station, Germany; Royal AFB, Lakenheath, England; Tinker AFB, Oklahoma; NUWC Keyport; and NSWC Crane.

Detachment Seal Beach played an integral role in Operational Demonstration II, which took place at the Marine Corps Air Ground Combat Center (MCAGCC) 29 Palms, CA in March 2004. The concept of the demonstration was to show the Marines how JDSR can streamline their maintenance and automate, consolidate, and minimize their documentation and administrative efforts.

The Equipment Support Division (ESD) at 29 Palms uses Maintenance Automation Program (MAP) to give its users the ability to input maintenance tasks via equipment repair orders (EROs) and parts requests. It also provides supervisor visibility to the status of all the equipment in the system, and access to the completed and open maintenance actions on all equipment within the ESD. MAP requires a full-time network connection.

For this demonstration, a Battalion maintenance unit was established in a deployed field environment. The unit had one MAP server and three MAP clients shared among the different repair units. The MAP clients exchanged ERO data collected during field operations with the MAP server via a low-bandwidth iridium satellite phone connection.

Without reinventing the wheel, Detachment Seal Beach was responsible for providing software engineering support to select the best solution and make any necessary changes so that the final maintenance and support tool would function in a stand-alone mode and integrate seamlessly into the JDSR environment. Detachment Seal Beach was successful in modifying the MAP software to operate on the JDSR ruggedized portable server accessed by multiple JDSR ruggedized laptop computers via satellite connections.

In addition, the modified MAP can interact with the TETS LAV-25 TPS Fault File/Fault History Data Base (FHDB) for ordering parts, and management can view EROs status using a web browser.

A marine operates a JDSR ruggedized laptop in the field during Operational Demonstration II. The demonstration took place at the Marine Corps Air Ground Combat Center in California. Photo courtesy of JDSR Program.

Detachment Seal Beach is the configuration manager for the Visual Automated Marine Corps Maintenance Program (VAMMP), which replaced Off-Line MAP in July of 2004. VAMMP is an enhanced version of the Visual Labmate (VLM) application widely used by the Marine Corps calibration communities. The program keeps track of all maintenance records and EROs for Marine Corps repair and calibration (e.g., light armored vehicles, etc.). VAMMP is constantly being improved and extended based on feedback from the returning troops.

The third demonstration, an excursion exercise, performed in 2004 successfully validated and proved the utility of many of the JDSR aspects. The exercise involved the Army teaming with the Marine Corps at a base near Reno, NV to prove the JDSR cross-service usage concept. In the demonstration scenario, soldiers on an Army Chinook CH-47 helicopter landed near a Marine Corps-type maintenance facility. Marines assisted the Army by helping them with maintenance on the helicopter. Using JDSR capabilities, Marines contacted an Army SME and were guided in diagnosing and resolving the maintenance problems.

JDSR has undergone many improvement cycles, and is continually being improved and adapted for different services and uses. Supporting the Marine Corps community, JDSR expands the scope to include a maintenance and support tool that improves and enhances the unit's ability to process EROs and order parts in a stand-alone, disconnected scenario.

JDSR, currently in extended user evaluation phase, is supporting deployed Marines with the 1st Marine Expeditionary Force (MEF) and soldiers of the Army's Striker Brigade in Operation Iraqi Freedom. It will also support 2nd MEF Marines when they deploy in support of the Global War on Terrorism.

Sailors aboard Navy ships such as guided-missile destroyer USS Mason, airmen at Spangdahlem Air Base in Germany, soldiers with the Army Reserve in Reno, NV, and Marines at Camp Pendleton, CA, are also currently utilizing JDSR capabilities.

JDSR provides warfighters with an easy, accessible tool for researching and obtaining data required to support their mission. JDSR has been proven to save time, manpower, and money, resulting in a valuable tool for our service members deployed around the world.

To learn more, please visit the JDSR website at http://www.jdsr.net.

Supporting the Warfighter: IHDIV Contributes to the Global War on Terrorism

Equipping the SRAW-MPV

IHDIV explosive-loaded 450 Mk 41 Mod 0 Short Range Assault Weapon - Multi Purpose Variant (SRAW-MPV) Warhead assemblies for NSWC, Dahlgren Division. IHDIV shipped 400 of these warhead assemblies to Lockheed-Martin for retrofitting the Predator Weapon System with a Direct Attack Warhead. These warheads are currently deployed in Iraq.

The SRAW-MPV is a further development of US Marine Corps' Predator anti-armor weapon intended for urban engagements. It utilizes technologies from Predator round while adding a new multi-purpose variant blast fragmentation warhead.

The SRAW-MPV changes the top-attack profile optimized for armored targets by a direct-fire mode, fully compatible with launch from enclosures. The warhead can be used against urban targets such as buildings, bunkers, and light armored vehicles. —*Bill Myers*

LAPAXA: Portable System Makes Large Package X-Ray Convenient and Efficient

The Large Package X-Ray Apparatus (LAPAXA) system, developed by engineers in the Weapons Simulation Department at IHDIV, provides explosive ordnance disposal (EOD) personnel with a portable device that allows them to unobtrusively locate the placement of an improvised explosive device (IED) inside large packages while in the field. The 1st Marine Expeditionary Force EOD Marines purchased seven LAPAXA systems for use in Operation Iraqi Freedom.

LAPAXA is a portable system with the capability for x-ray large-scale targets, such as 55-gallon drums. The unit can hold up to fifteen 8- by 10-inch standard EOD-issue Polaroid cassettes arranged in such a manner as to fully x-ray the target. The exposures can then be reassembled into a single image after development, with no gaps. The system's portability makes it ideal for use in combat. If a suspicious package, barrel, or any other item is found, equipment can be brought right in to the source, and within minutes it is known if there is an explosive device inside and what type it is.

— *Miguel Deleon*

An x-ray of a 55-gallon drum, taken with LAPAXA, shows that it contains an improvised explosive device (IED). Using the LAPAXA system, explosive ordnance disposal (EOD) personnel are able to investigate large suspect packages in the field.

Overcoming Launcher Shortage: 5-Inch LAU-10B/A Conversion

IHDIV developed a procedure for converting LAU-10B/A Launchers into LAU-10C/A and D/A Launchers to meet an immediate need in the Fleet. The Fleet was experiencing a shortage of the LAU-10C/A and D/A Launchers needed to launch the Mk 71 Mod 1 Zuni Rocket—there were no spare launchers. IHDIV personnel developed a conversion procedure using surplus LAU-10B/A launchers, retrofitting them into C/A and D/A launchers. After developing the procedure, IHDIV awarded a contract for conversion of these urgently needed launchers. Delivery of the converted launchers began in FY 04.

Sailors deploy probes used during a test of the Integrated Maritime Portable Acoustic Scoring and Simulation (IMPASS) system aboard USS O'Bannon in November 2002. IMPASS is part of the Virtual at Sea Training (VAST) system used to test the accuracy of shipboard weapons systems as well as live fire skills. Official U.S. Navy Photo by Photographer's Mate 1st Class Marthaellen L. Ball.

The 5.0-Inch Rocket System uses the four round LAU-10C/A (shore-based use only) and LAU-10D/A (shore-based or shipboard use) rocket launchers. The difference between the LAU-10C/A and LAU-10D/A reusable rocket launchers is the external thermal coating on the LAU-10D/A that greatly prolongs cook-off protection time. The unguided Zuni 5.0-Inch Rocket was originally developed for both air-to-air and air-to-ground applications, but is currently used almost exclusively in the latter role. —*Chuck Faulkler*

Qualifying Naval Surface Fire Support Teams: IMPASS Update

Since April 2003 and through FY 04, the IMPASS system has been used by the Atlantic Fleet to qualify the Naval Surface Fire Support teams on 21 surface combatant ships to an M M1 level of readiness. A ship's weapons systems must demonstrate this level of qualification before it can forward deploy to any of the active theaters of operation such as Iraq. Another 16 ships are scheduled to qualify using IMPASS in FY 05.

The IMPASS system concept is a low-cost, waterborne acoustic impact scoring system and simulator that lessens the Fleet's dependence on bombing ranges by allowing ships to conduct combat readiness training in the open ocean. IMPASS can transform an open-ocean area into a range suitable for live-fire exercises and supplementary training at sea for Navy and Marine Corps sea-air-ground combat units.

An IMPASS unit's acoustic sensors are built into seven buoys. Acting together, these buoys triangulate the location of any impact within 50 meters in relation to the actual fall-of-shot. —*Chris Rice*

Improving the 2.75-Inch Rocket Flechette Warhead

In September 2002, the Assistant Program Manager, Logistics (APML) for Rockets/JATOs at IHDIV was notified by NSWC Crane Division that a lot of WDU-4A/A 2.75-inch Flechette Warheads tested low on stabilizer content for the expulsion charge. The WDU-4A/A is a warhead used by the Marines in recent conflicts. Both IHDIV and NSWC Crane performed testing to determine the extent of the issue, and determined that there was no immediate safety or performance problem. The IHDIV APML, acting for NAVAIR PMA-242, secured 4,000 Flechette Warheads from the Air Force as no-cost excess units. When a test at IHDIV showed that the suspect warhead lot might experience dud problems within the next two years, Notice of Ammunition Reclassifications (NARs) were issued in March 2004 placing the lot in Condition Code H (condemned) and/or Condition Code N (emergency combat use). There were subsequent reports of some duds in Iraq.

IHDIV is currently working with industry to develop a replacement 2.75-inch Flechette Warhead which will have larger flechettes and be more effective against a broader range of targets. First buy of the new design is expected in the FY 05/06 timeframe. These actions demonstrate how IHDIV continues to support the warfighter in multiple roles, addressing problems and continuing to seek improvement in the weapons on which the warfighter depends. —*Chuck Faulkler*

Reducing Risk with Combat Safe Insensitive Munitions (CSIM)

by Mary H. Sherlock
Weapons Department

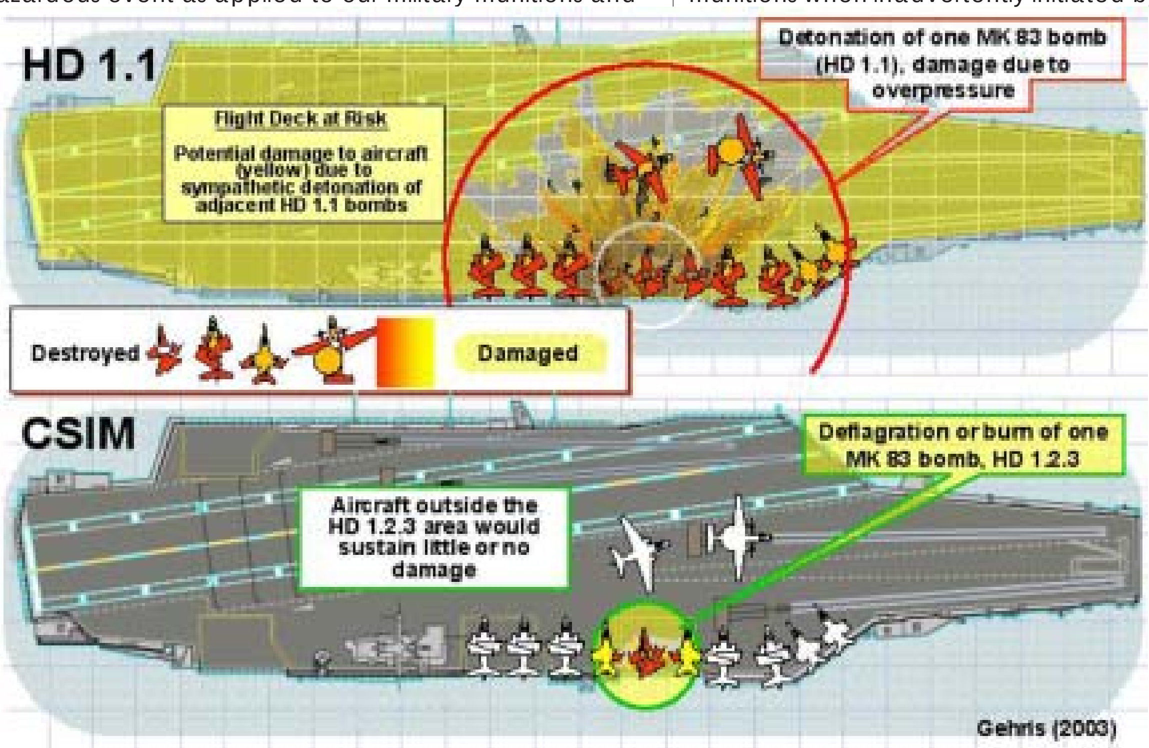
When exploring risks posed by a hazardous event scenario, two metrics are used: the likelihood of an event occurring, and the consequence of the event. Hence, there are two approaches to reducing the risk of a hazardous event occurring: mitigate the likelihood of the event occurring or reduce the consequence of a hazardous event if it occurs.

The Navy has made strides in significantly reducing the likelihood of munitions-related accidents over its history, particularly during the 38 years since the USS Forrestal accident.

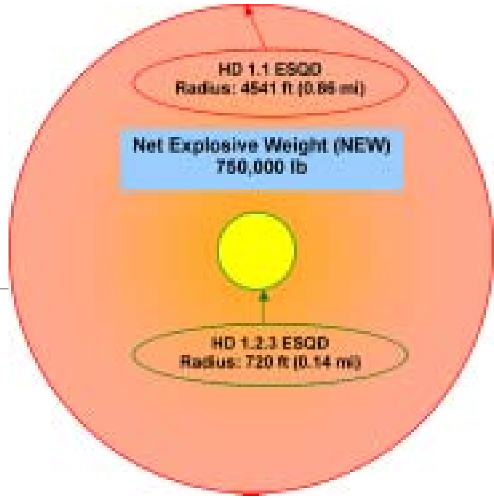
In the simplest of forms, Combat Safe Insensitive Munitions (CSIM) is focused on reducing the consequence of a hazardous event as applied to our military munitions and associated stockpiles.

CSIM benefits are intentionally focused on the combat life cycle, where munitions are in their most vulnerable of conditions and at the greatest risk. In peacetime, the military strictly adheres to explosive safety procedures. But combat conditions often result in insufficient safe separation and mixed weapons stows. Additionally, the munitions may not be in storage containers or protected magazines.

CSIM is the concept of ready service munitions that do not detonate adjacent munitions when inadvertently initiated by



This graphic shows the effect on the right deck of an HD 1.1 Mk 83 bomb detonation (top) versus an HD 1.2.3 Mk 83 bomb detonation. The CSIM deflagration has a much smaller arc of damage, thus enhancing survivability and warfighter capability.



This graphic shows the difference in the ESQD area for 750,000 lb net explosive weight depending on the HD category of the munitions. The hazard footprint of the HD 1.2.3 munitions (yellow circle) is 2.5 percent of the HD 1.1 footprint (peach circle).

accident or intent. An added benefit is that performance is not compromised, as weapons perform as well or better than non-CSIM munitions in the inventory.

Under the DOD Hazard Classification System, explosive items are allocated a hazard division (HD) that indicates the hazards presented by accidental initiation of the item. There are six categories associated with ammunition and explosives as follows:

HD 1.1 Mass Explosion
HD 1.2 Non-mass explosion, fragment producing
HD 1.3 Mass fire, minor blast, or fragment
HD 1.4 Moderate fire, no blast or fragment
HD 1.5 Explosive substance, very insensitive
HD 1.6 Explosive article, extremely insensitive.

A key element of DOD's explosive safety program is the use of explosive safety quantity-distance (ESQD) arcs, which provide protection to people, facilities, and material by maintaining a safe separation distance from the explosive. ESQD arcs, or hazard footprints, are determined by an analysis of the maximum credible event (MCE) resulting from the worst-case consequence for a given category and quantity of munitions in a given storage configuration. Although there have been drastic reductions in the likelihood of inadvertent initiation of munitions, most weapon stores are still classified as HD 1.1, whose MCE is a mass explosion.

An extensive, globally dispersed infrastructure exists today to store and manage the national munitions stockpile in order to ensure sustainability and surge capacities match with warfighter needs. One way to reduce the burden associated with the munitions infrastructure is to reduce the HD category, which in turn reduces the hazard footprint of a hazardous event.

The hazard footprint posed by the munitions stockpile includes the immediate area surrounding munition storage sites. For a largely HD 1.1 inventory, that translates into high, recurring manpower, equipment, and real estate costs for storing, handling, transporting, and maintaining this inventory, as well as restrictions on the operations that can be performed in the vicinity of the storage site.

HD 1.2 munitions present a fragmentation hazard, but do not present a mass explosion hazard. One subdivision of HD 1.2, HD 1.2.3, is referred to as Unit Risk Munitions, since the accidental detonation of one item does not result in the detonation of adjacent weapons. When amassed as a sizeable weapons inventory, HD 1.2.3 inventories have a much smaller hazard footprint than an equivalently sized HD 1.1 inventory.

The HD 1.2.3 characteristics of CSIM provide significantly reduced ESQD arcs. For example, consider a weapons inventory of 750,000 lb net explosive weight (NEW) at HD 1.1 and at HD 1.2.3. The ESQD arc for an HD 1.1 inventory is approximately 4541 ft. The ESQD arc for an HD 1.2.3 inventory is approximately 720 ft - roughly 2.5 percent of the land area of an equivalent HD 1.1 footprint. The hazard footprint for the HD 1.2.3 inventory is on the same order of magnitude as a pier or ship length.

Hazard footprint reductions of this magnitude represent significant cost savings, while drastically improving the readiness of our military with little impact to base operations.

A CH-46 Sea Knight transfers ordnance from the Military Sealift Command munitions ship USNS Kilauea to aircraft carrier USS Nimitz during a Vertical Replenishment. CSIM will provide greater flexibility and efficiency to support sealift, airlift, and underway replenishment operations. U.S. Navy Photo by Photographer's Mate Airman Maebel Tinoko.

By reducing the hazard footprint, CSIM provides greater flexibility and efficiency to load ships at ammunition piers; handle weapons in more ports; support sealift, airlift, prepositioning, and underway replenishment operations; and adapt to variable rates in ordnance movement. A CSIM inventory can also increase the NEW limits at air and sea ports of embarkation and debarkation, allowing more ordnance assets to be safe-havened or stored pending final shipment.

The CSIM concept would enable significant infrastructure innovations including:

- Joint, effective, adaptive, and flexible munition logistic concepts to sustain U.S. Forces to support variety of operational scenarios (Sea Basing)
- Flexibility to adopt operational efficiencies that increase sortie generation rates (Sea Strike)
- Enhanced survivability, force protection and preservation of fleet warfighting capabilities.

While there has been overwhelming enthusiasm for the CSIM concept from the Commander, Naval Air Force operational community and their weapons acquisition sponsor, Program Executive Officer, Strike Weapons and Unmanned Aviation (PEO(W)), CSIM can only be realized if the scientific merit can be assessed and supported by solid intellectual analysis.

The CSIM concept began as a paper on reduced hazard class munitions prepared by IHDIV's Karen Burrows and Ed Johnson. They based the paper on research performed by IHDIV's Research and Technology Department on small particle crystals, and international research on crystal quality to achieve measurable explosive insensitivity gains

NAVSEA's Integrated Warfare Systems Platform Systems Group (NAVSEA 05P) suggested shifting the focus of the concept to include the hazards of weapons exposed to combat conditions. On 12 June 2003, NAVSEA 05P provided a formal definition, survivability metrics, and the name, CSIM, to describe this concept.

Subsequently, the IHDIV Weapons Department and the IHDIV Research and Technology Department submitted a proposal to ONR under their Long Range Navy and Marine Corps Science and Technology Broad Agency Announcement. The proposal outlined the initial 18-month proof-of-concept and feasibility assessment for CSIM.

The premise behind the ONR's CSIM proof-of-concept research program is to examine and tailor the material properties of energetic materials to achieve measurable insensitivity gains. Historically, the baseline approach has been to improve insensitive munitions through the use of new energetic materials and formulations tailored to an application. Recent indications suggest that leap-ahead improvements can be made by mechanically customizing current state-of-the-art energetic materials to achieve a greater insensitivity to stimuli such as heat, shock, impact, shear, and friction.

Support for CSIM

IHDIV has been supporting the Office of Naval Research (ONR) in determining the warfighter utility of CSIM and garnering endorsements that will sustain a long-range commitment to realize CSIM goals. In July 2004, the Program Executive Officer, Strike Weapons and Unmanned Aviation (PEO(W)) provided an endorsement letter and technology transition pathway for CSIM.

"PEO(W) encourages ONR to pursue a proof-of-concept S&T program to demonstrate the feasibility of the CSIM concept. ...If successful, [PEO(W)] will help target, leverage, and facilitate its transition into strike weapon acquisition programs. PEO(W) supports the CSIM concept and will follow the progress of this proposed initiative with great interest into the future." — PEO(W)

Additionally, CSIM has been endorsed as an operational requirement. The Commander, Naval Air Force (CNAF) hosted an Aircraft Carrier Operational Advisory Group (OAG) meeting on 11-15 April 2005 at the Virginia Advanced Shipbuilding and Carrier Integration Center in Newport News, VA. IHDIV presented the CSIM concept at this forum to the Weapons Working Group, who subsequently endorsed CSIM as a future operational requirement.

An empirical study is underway through FY06 to assess the impact of crystal quality and particle size on the sensitivity of nitramine explosives, and may realize significant insensitivity improvements. Outyear proofs-of-concept include investigating metal fuels, oxidizers, binder characterizations, initiation modeling, and the development of computational codes to simulate the processing required to account for differences in geometry and rheological properties and to aid the flexibility of manufacturing a variety of energetic products.

The CSIM concept has operational endorsement, a transition partner, and funded proof-of-concept investments underway. The objective is to reduce the hazard footprint associated with munitions inventories with a focus on reducing the risk posed by our own munitions under combat conditions. If realized, CSIM will enable Joint, effective, adaptive, and flexible munition logistic concepts to sustain U.S. Forces.

"We have made exponential improvements in almost every facet of our ability to put warheads on foreheads, including training, aircraft, systems, terminal seekers, intelligence, surveillance, and reconnaissance (ISR), and battle damage assessment (BDA). Yet, we still use the basic bomb bodies, weapons logistics, loading and handling infrastructure that we went to war with 60 years ago. We need to move forward in this fundamental element of our business and CSIM seems to be the logical path and in the long run, makes the smart business case."

Captain Robert "Brick" Nelson, USN
Deputy Director, Deep Blue

As U.S. Forces continue to encounter new threats, IHDIV will remain vigilant in our quest to provide safe and effective energetic solutions for the warfighter. If these preliminary investments of assessing CSIM's scientific merit of through proof-of-concept and feasibility studies are successful, the CSIM concept will form the basis for future science and technology investment strategies that can yield intrinsically safe, high performance, and generation-after-next munitions.

IHDIV Works to Assure Reliability of Aircrew Escape Systems

by Todd Allen and Frank Valenta
CAD/PAD Department

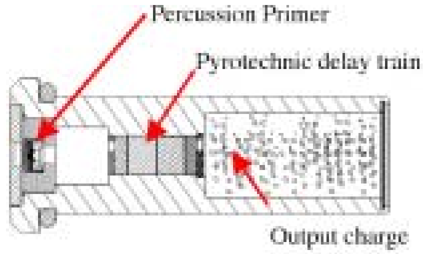
Employees in the CAD/PAD Department are working to ensure the safety of the warfighter by improving the methods of evaluating percussion primer performance. Percussion primers are a critical component in many mechanically actuated explosive and pyrotechnic devices used in the aircrew escape systems of high performance military aircraft.

The purpose of improving these methods is to increase confidence in the performance of the primers and to maximize the chance of identifying defective lots before they are used in man-rated escape system components. The engineers are taking extraordinary measures to make sure the primers in these man-rated escape systems are quality.

Although utilized in service, primers are not usually fired. However when they are called upon, a life is often on the line. Because primers in many of these systems present the potential for single point failure in an explosive device, it is extremely important that the primer is the highest quality and performs reliably.

To allow the identification and use of only the best primers for man-rated applications, IHDIV engineers are primarily interested in the comparative output performance between different lots of the

Following early morning bombing missions in support of Operation Enduring Freedom, an F-18 "Hornet" flies in the post-contact position during an aerial refueling mission. The F-18 aircraft's aircrew escape system has a number of critical components that use percussion primers. Improved primer testing will ensure that the aircrew escape system works properly if needed. U.S. Air Force photo by Tech Sgt. Scott Reed



The primer is a small, but critical, component in a typical cartridge used in a man-rated CAD. The cartridge is about 2.0-inch long by 0.6-inch in diameter.

The majority of IHDIV primers are used in aircrew escape systems that save warfighters' lives an an emergency.

same type of primer.

The current performance testing methods for percussion primers are based on industry standards, which are geared towards ammunition and small arms use—the most common industry use of primers. However, the majority of IHDIV primers are used in man-rated escape systems, and the industry standards are insufficient for such a critical use.

After manufacturing, or when IHDIV acquires a lot of primers, functional acceptance testing is performed, which includes sensitivity and reliability ("dud") testing. There are two ways the CAD/PAD department is looking to improve these evaluation methods. The first is to improve current acceptance test methods by eliminating subjective measurements. The second is to introduce additional tests to further qualify the primers.

Because primers are typically inexpensive, the traditional approach of assuring primer lot quality has been to "test the quality in" by firing enough primers from a lot to build confidence in the reliability of the lot. For some primer applications, IHDIV tests 2300 units from each lot (usually consisting of around 10,000 primers) with no misfires or "duds" permitted. This level of testing provides a minimum demonstrated reliability of 0.999 at the 90 percent confidence level for that lot.

Sound is the basis for determining if a primer functions properly in sensitivity and reliability drop tests. A positive result in the drop tests is determined by a subjective evaluation by the test operator as to whether the primer provided an appropriate output sound—did the primer provide an appropriate "bang" when struck?

In order to make such calls more objective, IHDIV has explored using various types of sound measuring equipment (from the basic microphone, to the more sophisticated audio spectrum analyzer) to capture sound and frequency information of a functioning primer. These data allowed for an objective determination and measurement of primer delay response and provided a quantitative measurement of its sound output.

Sensitivity is a determination of the energy needed to function a primer at a high level of reliability under a given set of conditions. Traditionally, sensitivity tests such as the Bruceton (staircase) and the so-called "run-down" tests have been used to determine sensitivity of a primer lot.

All primer lots are required to undergo sensitivity testing to help determine its sensitivity and reliability, but the testing is not very useful in providing information on the actual output characteristics of the primer. Output characteristics are another performance indicator of a given primer lot's quality.

For output testing of percussion primers, the most widely used approaches are either subjective judgments about the sound the primer produces or, in the area of ammunition, the velocity, action time, and consistency of standard ammunition rounds fired with primers from the lot.

Few other output measurement techniques have been widely accepted by the community, but IHDIV engineers are exploring the value of, and alternatives to, these options. Tests that could be performed to better characterize the output of precision primers include pressure measurements, optical measurements, and mechanical energy output.

Over the years, significant effort has been put into measuring primer output through pressure measurements. One of the easier to obtain and more meaningful measurements of primer performance is its pressure-time output. Pressure is generally a direct indication of the output energy of the primer, its brisance (shattering/crushing effect), and its ability to provide its output energy to the next energetic material in the explosive train. Pressure can be characterized using two test methods: closed bomb testing and vented bomb testing.

A PVU-12/A primer with a tripod anvil uses less than 0.0004 lb explosive composition, and is easily dwarfed by this quarter. Percussion primers, although quite small and simple in design, are critical to the successful performance of sophisticated aircrew escape systems.

Pressure time has long been proposed as an acceptance criteria for percussion primers. While there are problems with closed bomb testing—closed bombs do not deal well with predicting mass flow, accounting for heat loss, or characterizing deflagrating or shock outputs — results provide good information on lot-to-lot differences that may exist between primer lots. IHDIV is currently working with Los Alamos National Laboratory on closed bomb technology to characterize lot-to-lot differences in percussion primers.

Vented bombs have been pursued as engineering tools to more completely characterize the output of percussion primers. Vented bombs solve some of the problems experienced with closed bombs. For example, since the functioning period in vented bomb firings is short, losses from heat transfer are held to a minimum, and mass flow can be calculated using rocket motor equations. Although IHDIV pursued using vented bomb for acceptance testing of percussion primers, the vented bomb approach was determined to be too experimental in nature and not suitable for including into primer acceptance procedures at this time.

Optical measurements are another avenue IHDIV engineers are exploring to better evaluate primer output. Engineers have tried several optical methods with mixed results. One approach included measuring the flame (light) intensity and duration using a photo cell; another measured the flame length using a video or still camera. Such results are often quite spectacular but the data gained is often difficult to convert to meaningful engineering information on primer performance in the end item.

Engineers also evaluated use of a high-speed two-color pyrometer with primers. This approach, although very good at differentiating between primer types and measuring the dynamic properties of the primer output plume, was not characterized to the extent that it could be called out as an acceptance test for percussion primers.

Percussion primers, as small explosive devices that produce pressure and shock, have the capacity to do mechanical work. Perhaps the most well known application of this principle is the McAir energy tester that was developed to evaluate the output of shielded mild detonating cords. In the McAir energy tester, primer output is used to drive a piston that compresses/crushes a calibrated aluminum honeycomb material.

This photograph shows the primer line at one of IHDIV's cartridge manufacturing technology facilities where percussion primers are manufactured. Improved acceptance testing methods would further ensure the quality of the primers used in aircrew escape systems.

The McAir energy tester does not provide any information on energy-time and, in testing at IHDIV, occasionally provided results that were variable and appeared to be inconsistent with those of other tests. Because of heat losses and frictional forces, as well as pressurization rate differences, engineers found that the McAir energy tester may not be well suited for characterizing lower output primers (i.e., those of interest to IHDIV).

Although there have been many efforts to develop improved methods of monitoring the quality of percussion primers, none have yet gained the wide acceptance and use in lot acceptance testing or quality evaluation programs. These new test methods are still in the research phase, and have yet to be incorporated into testing specifications. More testing is needed to provide confidence that the new tests are providing accurate and necessary data.

Even though new test methods being evaluated at IHDIV have not been finalized or incorporated, they have the potential to contribute to a better evaluation of primer performance, resulting in greater confidence in primers that are deployed in the aircrew escape systems of high performance military aircraft. IHDIV remains committed to exploring new and more reliable ways to test percussion primer performance, and protect the life of the warfighter.

A ball drop test fixture is used to determine the sensitivity of a primer lot.

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